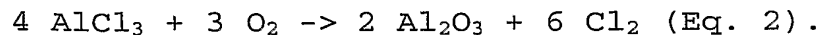


**Aluminium oxide powder produced by flame hydrolysis and  
having a large surface area**

The present invention relates to an aluminium oxide powder  
5 produced by flame hydrolysis and having a large surface  
area, and to its production and use.

It is known to produce aluminium oxide powder by means of  
pyrogenic processes. Pyrogenic processes include flame  
hydrolysis, in which an aluminium halide, generally  
10 aluminium chloride, is hydrolysed at high temperatures with  
the formation of aluminium oxide and hydrochloric acid  
according to Eq. 1.



15 Aluminium oxide C, Degussa AG, for example, is produced in  
this manner. Aluminium oxide C has a surface area of  
approximately 90 m<sup>2</sup>/g.

A further aluminium oxide powder produced by flame  
hydrolysis is the powder from Cabot. It has a BET surface  
20 area of 55 m<sup>2</sup>/g and comprises about 56 % theta and 20 %  
delta crystal modifications as well as 24 % amorphous  
constituents.

EP-A-1083151 describes an aluminium oxide powder having a  
BET surface area of more than 115 m<sup>2</sup>/g, which powder at the  
25 same time has a Sears index of more than 8 ml/2 g and the  
dibutyl phthalate absorption of which cannot be determined.  
The example describes a powder having a BET surface area of  
121 m<sup>2</sup>/g and a Sears index of 9.38 ml/2 g.

US 3663283 describes a process for the production of metal  
30 oxide powders by flame hydrolysis. Although an example  
relating to aluminium oxide is given, the aluminium oxide

is described only as being finely divided with narrow particle distribution. Further details are not given.

In US 5527423 there is claimed a dispersion that contains precipitated aluminium oxide or aluminium oxide produced by flame hydrolysis having a BET surface area of from 40 to 430 m<sup>2</sup>/g. The manner in which such aluminium oxide powders are obtained is not disclosed, however. In the examples, aluminium oxide powders having a BET surface area only within a narrow range of from 55 to 100 m<sup>2</sup>/g are disclosed.

In EP-A-1256548, aluminium oxide particles are disclosed having a mean primary particle diameter of from 5 to 100 nm and a mean aggregate diameter of from 50 to 80 nm are. The particles may be amorphous or crystalline. The proportion of particles larger than 45 µm is preferably 0.05 wt.% or less. These aluminium oxide particles are said to be obtainable by a gas-phase reaction of aluminium chloride with oxygen and/or steam, wherein the reactants are pre-heated, at temperatures of about 800°C and subsequent separation of the aluminium oxide that is formed from gaseous substances. Oxygen, water and oxygen/water mixtures are to be used as the oxidising agents in the reaction.

This reaction is, however, a gas-phase reaction, not flame hydrolysis or flame oxidation. The powder obtained in accordance with EP-A-1256548 has a different structure and different properties than a powder obtained by flame hydrolysis or flame oxidation. For example, the proportion of chloride may be up to several wt.%. The powder can have an undesirable grey colour, which may be attributable to aluminium oxychloride constituents resulting from the incomplete reaction of aluminium chloride.

Many possible uses of aluminium oxide powders are known. They are used in the paper industry, in particular in ink-jet papers. Aluminium oxide powders affect, *inter alia*, the gloss, the brilliance of colour, the adhesion and the ink

absorption. The increasing demands that are made of ink-jet papers require the values of these parameters to be improved.

Aluminium oxide powders are also used as an abrasive in  
5 dispersions for polishing oxidic and metallic coatings in the electronics industry (chemical mechanical polishing, CMP). Here too, the continued miniaturisation of the components requires customised abrasives which allow  
10 surfaces in the nanometre range to be polished without scratching.

The object of the invention is to provide an aluminium oxide powder that meets the increased demands in the fields of ink-jet and CMP. In particular, it should be possible to incorporate the powder into dispersions easily and with  
15 high degrees of filling. A further object of the invention is a process for the production of such a powder.

The invention provides an aluminium oxide powder produced by flame hydrolysis and consisting of aggregates of primary particles, which powder is characterised in that  
20 - it has a BET surface area of from 100 to 250 m<sup>2</sup>/g,  
- the dibutyl phthalate absorption is from 50 to 450 g/100 g of aluminium oxide powder, and  
- it shows only crystalline primary particles on high-resolution TEM pictures.

25 The aluminium oxide powder according to the invention preferably has an OH density of from 8 to 12 OH/nm<sup>2</sup>.

The chloride content of the aluminium oxide powder according to the invention is preferably less than 1.5 wt.%.

30 It is also preferred for the proportion of particles having a diameter greater than 45 µm to be in a range of from 0.0001 to 0.05 wt.%.

Preference may also be given to an aluminium oxide powder according to the invention which in the X-ray diffractogram exhibits an intensity, expressed as the counting rate, of more than 50 at an angle  $2\theta$  of  $67^\circ$ .

- 5 Such an aluminium oxide powder may exhibit the signals of gamma-, theta- and/or delta-aluminium oxide in the X-ray diffractogram, the signal of gamma-aluminium oxide generally being the most intense.

10 It is also possible for the aluminium oxide powder according to the invention to exhibit in the X-ray diffractogram an intensity, expressed as the counting rate, of less than 50 at an angle  $2\theta$  of  $67^\circ$ . Such a powder is X-ray amorphous to the greatest possible extent.

- Preference may be given to an aluminium oxide powder
- 15 - in which the BET surface area is from 120 to 200 m<sup>2</sup>/g, the dibutyl phthalate absorption is from 150 to 350 g/100 g of aluminium oxide powder, the OH density is from 8 to 12 OH/nm<sup>2</sup>, and which
- 20 - shows only crystalline primary particles in high-resolution TEM pictures, and which
- in the X-ray diffractogram has signals with an intensity, expressed as the counting rate, of more than 50 at an angle  $2\theta$  of  $67^\circ$ , and exhibits signals of gamma-, theta- and/or delta-aluminium
- 25 oxide.

In such a powder, a BET surface area of from 125 to 150 m<sup>2</sup>/g is particularly preferred.

Preference may further be given to an aluminium oxide powder

- 30 - in which the BET surface area is from 120 to 200 m<sup>2</sup>/g, the dibutyl phthalate absorption is from 150 to 350 g/100 g of aluminium oxide powder, the OH density is from 8 to 12 OH/nm<sup>2</sup>, which powder

- shows only crystalline primary particles in high-resolution TEM pictures and
- in the X-ray diffractogram exhibits an intensity, expressed as the counting rate, of less than 50 at an angle  $2\theta$  of  $67^\circ$ .

In the case of such a powder, a BET surface area of from 135 to 190 m<sup>2</sup>/g is particularly preferred.

The invention further provides a process for the production of the aluminium oxide powder according to the invention, in which

- aluminium chloride is vaporised, the vapour is transferred by means of a carrier gas to a mixing chamber and,
- separately therefrom, hydrogen, air (primary air), which may optionally be enriched with oxygen and/or may optionally be pre-heated, are supplied to the mixing chamber, then
- the mixture of aluminium chloride vapour, hydrogen and air is ignited in a burner and the flame burns into a reaction chamber that is separated from the surrounding air,
- the solid material is subsequently separated from gaseous substances, and
- the solid material is then treated with steam and optionally with air,
- the discharge rate of the reaction mixture from the mixing chamber into the reaction chamber being at least 10 m/s, and
- the  $\lambda$  value being from 1 to 10 and
- the  $\gamma$  value being from 1 to 15.

The structure of the aluminium oxide powders according to the invention in respect of their X-ray crystalline or X-ray amorphous state can be controlled by varying the aluminium chloride concentration in the gas stream. High

aluminium oxide concentrations in the gas stream yield an X-ray crystalline powder.

The definition of a high aluminium chloride concentration is dependent on the structure of the reactor; a range from  
5 0.2 to 0.6 kg of  $\text{AlCl}_3/\text{m}^3$  of gas can be used as a reference point for a production installation.

If the aluminium chloride concentration in the same production installation is multiplied by a factor of from 0.4 to 0.6, a powder that is X-ray amorphous to the  
10 greatest possible extent is obtained.

In addition to adjustments that yield X-ray crystalline powders or powders that are X-ray amorphous to the greatest possible extent, it is also possible, by varying the aluminium concentration in the gas stream, to obtain  
15 powders that, for example, contain a defined proportion of X-ray amorphous aluminium oxide.

In a particular embodiment of the process according to the invention, a secondary gas consisting of air and/or nitrogen can be introduced into the reaction chamber. The  
20 ratio primary air/secondary gas preferably has values of from 10 to 0.5. The introduction of a secondary gas can help to avoid caking in the reaction chamber.

The invention relates also to the use of the aluminium oxide powder according to the invention as an ink-absorbing  
25 substance in ink-jet media.

The invention relates also to the use of the aluminium oxide powder according to the invention as an abrasive.

The invention relates also to the use of the aluminium oxide powder according to the invention in dispersions.

30 The invention relates also to the use of the aluminium oxide powder according to the invention as a filler, as a carrier, as a catalytically active substance, as a ceramics

base, in the electronics industry, in the cosmetics industry, as an additive in the silicone and rubber industry, for adjusting the rheology of liquid systems, for heat stabilisation, in the surface coatings industry.

5

### Examples

#### Analysis

The BET surface area of the particles is determined in accordance with DIN 66131.

- 10 The X-ray diffractograms are determined by means of a transmission diffractometer from Stoe & Cie Darmstadt, Germany. The parameters are: CuK alpha radiation, excitation 30 mA, 45 kV, OED.

- The dibutyl phthalate absorption is measured with a  
15 RHEOCORD 90 device from Haake, Karlsruhe. For that purpose, 16 g, accurate to 0.001 g, of the aluminium oxide powder are introduced into a kneading chamber, the chamber is closed with a lid, and dibutyl phthalate is metered in through a hole in the lid at a predetermined metering rate  
20 of 0.0667 ml/s. The kneader is operated at a motor speed of 125 revolutions per minute. When the maximum torque is reached, the kneader and the DBP metering are automatically switched off. From the amount of DBP that has been consumed and the quantity of particles weighed in, the DBP  
25 absorption is calculated as follows:

$$\text{DBP number (g/100 g)} = (\text{DBP consumption in g} / \text{weighed portion of particles in g}) \times 100.$$

- The hydroxyl group density is determined in accordance with the method published by J. Mathias and G. Wannemacher in  
30 Journal of Colloid and Interface Science 125 (1988), by reaction with lithium aluminium hydride.

Measurement of the Sears index is described in EP-A-717008.

$\gamma = \text{H}_2 \text{ supplied/stoichiometrically required H}_2$

$\lambda = \text{O}_2 \text{ supplied/stoichiometrically required O}_2$

5 **Example 1:**

2.76 kg/h of  $\text{AlCl}_3$  are vaporised in a vaporiser. The vapours are transferred by means of an inert gas (2.00  $\text{Nm}^3/\text{h}$ ) to a mixing chamber. Separately therefrom, 3.04  $\text{Nm}^3/\text{h}$  of hydrogen and 10.00  $\text{Nm}^3/\text{h}$  of air are  
10 introduced into the mixing chamber. In a central pipe, the reaction mixture is fed to a burner and ignited. The discharge rate of the reaction mixture from the burner is 31.4 m/s. The flame burns into a water-cooled flame tube. 20  $\text{Nm}^3/\text{h}$  of secondary air are additionally introduced into  
15 the reaction chamber. The powder that forms is separated off in a downstream filter and then treated countercurrently with air and steam at about 600°C. The physico-chemical data of the powder are shown in Table 2.

Examples 2 to 8 are carried out analogously to Example 1.  
20 The process parameters and the physico-chemical data of the powders are to be found in Table 1.

Figure 1A shows the X-ray diffractogram of the powder from Example 1, Figure 1B shows that of the powder from Example 4. The X-ray diffractogram of the powder from  
25 Example 1 clearly shows the signals of aluminium oxide modifications. The powder from Example 4, on the other hand, shows only a very weak signal at  $2\theta = 67^\circ$  and is to be characterised as X-ray amorphous to the greatest possible extent. The primary particles of both powders  
30 consist of crystalline primary particles. Figure 2 shows a high-resolution TEM picture of the powder from Example 4, which shows this situation.



Table 1: Process settings and physico-chemical data of the Al<sub>2</sub>O<sub>3</sub> powders

Example		1	2	3	4	5	6	7	8
AlCl <sub>3</sub>	kg/h	2.76	2.76	2.76	1.25	1.25	1.25	1.25	1.25
Hydrogen	Nm <sup>3</sup> /h	3.04	3.04	3.04	1.90	1.9	1.9	0.5	3.5
Primary air	Nm <sup>3</sup> /h	10.00	9.15	9.5	13.50	13	13.8	8.25	15
Secondary air	Nm <sup>3</sup> /h	20.00	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Inert gas	Nm <sup>3</sup> /h	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Total gases	Nm <sup>3</sup> /h	35.04	34.19	34.54	37.4	36.9	37.7	30.75	40.5
AlCl <sub>3</sub> /Total gases	kg/Nm <sup>3</sup>	0.079	0.081	0.080	0.033	0.034	0.033	0.041	0.031
gamma <sup>#</sup>		4.37	4.37	4.37	6.03	6.03	6.03	1.59	11.1
lambda <sup>#</sup>		1.38	1.26	1.31	7.38	7.27	7.45	6.91	1.79
v <sub>B</sub> <sup>*</sup>	m/s	31.4	29.7	30.4	35.4	34.0	36.0	22.9	43.4
BET surface area	m <sup>2</sup> /g	175	104	125	181	124	195	192	101
XRD counting rate at 2 theta=67°		400	500	650	15	5	0	22	10
DBP number	g/100g	280	160	204	284	215	315	301	154
OH density	OH/nm <sup>2</sup>	8.7	8.1	10.5	8.9	11.4	8.9	11.1	9.6
Sears index	ml/2g	15.3	17.8	24.5	23.1	25.3	227	24.5	21.5
pH		5.3	5.1	5.4	5.5	5.5	5.1	5.2	5.3
Bulk density	g/l	20	19	18	20	21	20	19	19
Tamped density	g/l	26	24	—	28	25	28	31	27
Chloride content	wt. %	1.2	0.8	1.0	1.3	0.9	1.4	1.4	0.7
Proportion > 45 µm	%								

\*v<sub>B</sub> = discharge rate at the mouth of the burner; # based on core gases primary air, hydrogen, inert gas